Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

NORTHERN FOREST EXPERIMENT STATION
JUNEAU, ALASKA
U. S. DEPARTMENT OF AGRICULTURE

F99.9
F7672U
cop. 2

U. S. FOREST SERVICE

RESEARCH NOTE NOR-3

U. S. DEPT. OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY
NOV 20 1963
C & R-PREP.

May 1963

AERIAL PHOTO VOLUME TABLES FOR INTERIOR ALASKA TREE SPECIES

Paul M. Haack

Aerial photo volume tables have particular utility for extensive forest inventories of large, remote areas. Much field time and travel cost can be saved, yet the sampling precision can be kept within set goals.

The tables in this report were developed mainly for the inventory[1] of 230 million acres of Alaska's interior. However, other land managers may also find them of value.

FIELD DATA

Current aerial photograph coverage of five general areas was used in the study. Photo scales varied from 1:2,400 to 1:14,000 with the majority around 1:5,000. Prints from infra-red film exposed with a minus blue filter predominated. This type was later chosen for the inventory.

Various forest condition classes, each at least one acre in extent, were located on the photos. One-half-acre field plots were established within these condition classes and marked on the photos. Trees were tallied by heights and diameters. Only plots on productive forest land were used to develop the tables. At least 80 percent of the total crown closure (in trees 5.0 inches diameter breast height and larger) was required to be in a single major species-type.

---

[1] Part of the Forest Survey project of the U. S. Forest Service.

DEVELOPING THE TABLES

Gross cubic-foot volume per acre for all live trees 5.0 inches d.b.h. and larger was derived from tree volume tables based on 1-inch d.b.h. and 5-foot height classes.[2] Gross board-foot volume per acre for white spruce (Picea glauca) and black spruce (P. mariana) 9.0 inches d.b.h. and larger, paper birch (Betula papyrifera), quaking aspen (Populus tremuloides), and poplar (mainly P. balsamifera) 11.0 inches d.b.h. and larger, was compiled from tree volume tables.[2] Tamarack (Larix laricina) was included with spruce. Gross plot volume was correlated with two basic variables: (1) average height of the five tallest trees of the predominant species as measured from the ground, and (2) crown closure, of live trees 5.0 inches d.b.h. and larger from micro-dot-grid counts on aerial photos.

Gross plot volume was plotted over various powers, combinations, and logarithmic transformations of the basic independent variables. The most promising independent variables for species and species groups were used in regression analyses.[3] The best predictive equation is given beneath each table.

ESTIMATING VOLUME FOR MIXED STANDS

Plots in 23 mixed stands (stands with associated species comprising over 20 percent of the crown closure) were analyzed. It was hypothesized that the volumes for the spruce and hardwood components were predictable from the aerial photo volume tables based on the height and crown closure classes of each component, disregarding possible covariance.

Field volumes were graphed over tabular volumes for each species component and for all species combined. The mean differences between field and tabular volumes for the cubic- and board-foot hardwood components were highly significant. After adjustment by regression, the mean differences were not significant. Cubic- and board-foot spruce volumes required no adjustments. Logical relationships were maintained in the volume distribution among stand components. Thus, volume in mixed stands can be predicted as follows:

---

[2] Haack, Paul M. Tree volume tables for interior Alaska tree species. 1963. (In preparation for publication, Northern Forest Expt. Sta., U. S. Forest Serv., Juneau, Alaska.)

[3] Boles, James N. 40-series--stepwise regression system. Cal. Agr. Expt. Sta., Dept. of Agr. Econ., U. of Cal., Berkeley, 43 pp. dittoed, June 1962.

	Objective	Predictor
(1)	Spruce component, cu. ft./a	Table 1 value
(2)	Hardwood component, cu. ft./a	(Table 3 value) (1.366)
(3)	Plot total, cu. ft./a	(1) + (2)
(4)	Spruce component, bd. ft./a	Table 2 value
(5)	Hardwood component, bd. ft./a	(Table 4 value) + 400
(6)	Plot total, bd. ft./a	(4) + (5)

CONSIDERATIONS

Volumes varied considerably within height-crown closure classes. Practicability and the extensiveness of the first Interior forest inventory precluded more plots over a wider range of field conditions in an attempt to reduce this variance. Though volume estimates for individual plots may be far off, the equations and tables predict gross volume for an inventory unit within acceptable limits. Since more variability was encountered in the board-foot tables, crown diameter as an additional variable warrants testing in future work. Crown diameter may strengthen functions of height and crown closure in predicting volumes of sawtimber-size trees.

Note that the square of cubic-foot volume per acre is used as an independent variable in both the spruce and hardwood board-foot predictions. Until this term was included in the whole array of independent variables tested, only stand height and the square of stand height were found significant, with the resulting equations of very poor precision. Thus, the cubic-foot volume of a plot must first be estimated by equation or table and then the square of this value (including its inherent error) used to improve the board-foot prediction.

Using the equations instead of the tables may have some advantages, but certain precautions are needed. First, if the equation gives a negative value it must be set to zero. Second, for spruce board-foot estimates, anomalous results are obtained around 5 percent density and 40- to 55-foot height classes in that values far greater than zero are obtained, yet zero cubic-foot volumes for these stand conditions prevail. One cannot have board-foot volume when no cubic-foot volume exists, at least as estimated from an equation of greater precision. Once these adjustments are made, the use of the equations does avoid any additional bias caused by broad height-density classes. However, it is questionable if photo measurements of height and density can be made more accurately than to these broad classes, but surely no harm results. High-speed computer analysis is usually more efficient using volume equations than stored volume tables.

Board-foot estimates are conservative since included in their preparation are data from stands which do not necessarily meet the definition for sawtimber.[4] To a lesser degree, the cubic-foot predictions are conservative in that not all plots used in their construction meet the definition for poletimber and larger stands. This has a smoothing effect on volume predictions for any misclassified plots, however.

Note particularly that in the spruce cubic-foot and board-foot tables a re-curving of volumes occurs over most height classes. Though the magnitude of this phenomenon appears great especially across the lower height classes, the condition itself can be explained--the tree diameters tend to be smaller with increasing crown closure. This same condition, though of lesser degree, was encountered by Pope.[5]

4/ At the time of this study, the definitions were:

a. Sawtimber stands. Stands at least 10 percent stocked with growing-stock trees whereon the net sawtimber volume averages at least 1,500 bd. ft. per acre.
b. Poletimber stands. Stands at least 10 percent stocked with growing-stock trees whereon the sawtimber definition is not met but at least 250 cu. ft. net/a. in poletimber and larger trees is realized.
c. Sapling-seedling stands. Stands at least 10 percent stocked with growing-stock trees whereon the above two definitions are not met.

5/ Pope, Robert B. Aerial photo volume tables for Douglas-fir in the Pacific Northwest. Pacific NW Forest & Range Expt. Sta. Res. Note 214, 8 pp., 1961.

Table 1.--Aerial photo volume table for spruce, interior Alaska[1]

(In cubic feet per acre)

Height[2]	Crown closure (percent)[3]										Basis: plots measured[4]
	5	15	25	35	45	55	65	75	85	95	
Feet											Number
35	0	125	243	236	103	0	0	0	0	0	3
40	0	204	374	419	340	135	0	0	0	0	4
45	0	283	505	603	576	424	147	0	0	0	4
50	0	361	636	787	812	713	488	139	0	0	3
55	0	440	768	970	1,048	1,001	829	533	111	0	8
60	14	519	899	1,154	1,284	1,290	1,170	926	557	63	2
65	40	598	1,030	1,338	1,521	1,578	1,512	1,320	1,003	562	8
70	66	676	1,161	1,521	1,757	1,867	1,853	1,713	1,449	1,060	18
75	93	755	1,292	1,705	1,993	2,156	2,194	2,107	1,895	1,559	11
80	119	834	1,424	1,889	2,229	2,444	2,535	2,501	2,341	2,057	2
85	145	912	1,555	2,072	2,465	2,733	2,876	2,894	2,788	2,556	4
90	171	991	1,686	2,256	2,701	3,022	3,217	3,288	3,234	3,054	2
95	198	1,070	1,817	2,440	2,938	3,310	3,558	3,681	3,680	3,553	1
100	224	1,149	1,948	2,624	3,174	3,599	3,899	4,075	4,126	4,052	--
105	250	1,227	2,080	2,807	3,410	3,888	4,241	4,469	4,572	4,550	--
110	276	1,306	2,211	2,991	3,646	4,176	4,582	4,862	5,018	5,049	--
115	303	1,385	2,342	3,175	3,882	4,465	4,923	5,256	5,464	5,547	--
120	329	1,463	2,473	3,358	4,118	4,754	5,264	5,650	5,910	6,046	--
125	355	1,542	2,605	3,542	4,355	5,042	5,605	6,043	6,356	6,545	--

---

[1] Per acre gross volume (inside bark, from one-foot stump to not less than 4.0-inch top) for all live trees at least 5.0 inches d.b.h. $= V = -285.4308 - 0.62433\,C^2 + 1.04965\,CH$. $R^2 = 0.812$. Standard error of estimate as percent of mean volume: for equation, 27.6%; for table, 28.1%.

[2] Average height, H, of 5 tallest spruce. Interval as $62.6 \leq 65 < 67.6$.

[3] C, from micro-dot grid counts of all live trees at least 5 inches d.b.h. Interval as $60.0 \leq 65 < 70.0$.

[4] Lines contain basic data for 70 1/2-acre plots from 5 general areas.

Northern Forest Experiment Station
U. S. Forest Service
Juneau, Alaska
Research Note No. 3, May 1963

Table 2.--Aerial photo volume table for spruce, interior Alaska[1]

(In board feet per acre)

Height[2]	Crown closure (percent)[3]										Basis: plots measured[4]
	5	15	25	35	45	55	65	75	85	95	
Feet											Number
35	0	0	0	0	0	0	0	0	0	0	3
40	0	107	176	166	33	0	0	0	0	0	4
45	0	373	508	551	424	134	0	0	0	0	4
50	0	678	897	1,023	936	613	98	0	0	0	3
55	0	1,021	1,344	1,582	1,579	1,264	650	0	0	0	8
60	1,170	1,403	1,849	2,228	2,343	2,085	1,428	432	0	0	2
65	1,513	1,823	2,412	2,960	3,231	3,077	2,431	1,315	0	0	8
70	1,886	2,282	3,033	3,778	4,244	4,239	3,660	2,486	784	0	18
75	2,286	2,779	3,712	4,684	5,381	5,573	5,114	3,946	2,094	0	11
80	2,716	3,315	4,448	5,676	6,642	7,077	6,794	5,694	3,762	1,068	2
85	3,174	3,889	5,243	6,755	8,028	8,751	8,699	7,731	5,790	2,906	4
90	3,661	4,502	6,096	7,920	9,538	10,597	10,830	10,055	8,176	5,181	2
95	4,177	5,153	7,006	9,172	11,172	12,613	13,186	12,668	10,921	7,893	1
100	4,721	5,843	7,975	10,511	12,931	14,800	15,768	15,569	14,025	11,041	--
105	5,293	6,571	9,002	11,937	14,814	17,158	18,575	18,759	17,488	14,627	--
110	5,895	7,338	10,086	13,449	16,822	19,686	21,607	22,237	21,310	18,649	--
115	6,525	8,144	11,228	15,047	18,953	22,385	24,865	26,003	25,491	23,109	--
120	7,184	8,987	12,429	16,733	21,210	25,255	28,349	30,057	30,031	28,005	--
125	7,871	9,870	13,687	18,505	23,590	28,295	32,058	34,400	34,929	33,338	--

---

[1] Gross volume per acre in International 1/4" rule (from one-foot stump to top equaling 40% of d.b.h. but not under 6.0 inches) for all live spruce at least 9.0 inches d.b.h. and occasional hardwoods over 11.0 inches. = $V = -802.4264 + 0.54788\ H^2 - 0.000001\ C^3H^2 + 0.00091\ V^2$ cu.ft./a.

$R^2 = 0.926$. Standard error of estimate as percent of mean volume: for equation, 26.8%; for table, 49.4%.

[2] Average height, H, of 5 tallest spruce. Interval as $62.6 \leq 65 < 67.6$.

[3] C, from micro-dot grid counts of all live trees at least 5 inches d.b.h. Interval as $60.0 \leq 65 < 70.0$.

[4] Lines contain basic data for 70 1/2-acre plots from 5 general areas.

Northern Forest Experiment Station
U. S. Forest Service
Juneau, Alaska
Research Note No. 3, May 1963

Table 3.--Aerial photo volume table for hardwoods, interior Alaska[1]

(In cubic feet per acre)

Height[2]	Crown closure (percent)[3]										Basis: plots measured[4]
	5	15	25	35	45	55	65	75	85	95	
Feet											Number
35	51	59	67	75	83	91	99	107	115	123	5
40	61	89	116	144	172	200	228	256	284	311	12
45	73	125	178	230	282	335	387	439	492	544	6
50	88	169	250	332	413	495	576	658	739	821	16
55	104	220	335	450	566	681	796	911	1,027	1,142	9
60	124	277	431	585	739	892	1,046	1,200	1,354	1,507	18
65	145	342	539	736	933	1,130	1,326	1,523	1,720	1,917	21
70	169	414	659	903	1,148	1,393	1,637	1,882	2,127	2,371	5
75	195	493	790	1,087	1,384	1,681	1,978	2,275	2,572	2,870	5
80	224	578	932	1,287	1,641	1,995	2,350	2,704	3,058	3,412	--
85	255	671	1,087	1,503	1,919	2,335	2,751	3,167	3,583	3,999	--
90	288	771	1,253	1,736	2,218	2,701	3,183	3,666	4,148	4,631	--
95	324	877	1,431	1,985	2,538	3,092	3,645	4,199	4,753	5,306	--
100	362	991	1,620	2,250	2,879	3,509	4,138	4,768	5,397	6,026	--
105	402	1,112	1,822	2,531	3,241	3,951	4,661	5,371	6,081	6,791	--
110	444	1,239	2,034	2,829	3,624	4,419	5,214	6,009	6,804	7,599	--
115	489	1,374	2,259	3,144	4,028	4,913	5,798	6,683	7,568	8,452	--
120	536	1,516	2,495	3,474	4,453	5,433	6,412	7,391	8,370	9,350	--
125	586	1,664	2,743	3,821	4,899	5,978	7,056	8,134	9,213	10,291	--
130	638	1,820	3,002	4,184	5,366	6,549	7,731	8,913	10,095	11,277	--

---

[1] Per acre gross volume (inside bark, from one-foot stump to not less than 4.0-inch top) for all live trees at least 5.0 inches d.b.h. $= V = 46.8259 - 0.30357\ CH + 0.00933\ CH^2$. $R^2 = 0.895$. Standard error of estimate as percent of mean volume: for equation, 27.3%; for table, 26.3%. (components: balsam poplar, 22.2%; birch, 25.7%; aspen, 33.3%).

[2] Average height, H, of 5 tallest aspen, birch, or balsam poplar. Interval as $62.6 \leq 65 < 67.6$.

[3] C, from micro-dot grid counts of all live trees at least 5 inches d.b.h. Interval as $60.0 \leq 65 < 70.0$.

[4] Lines contain basic data for 97 1/2-acre plots from 5 general areas.

Northern Forest Experiment Station
U. S. Forest Service
Juneau, Alaska
Research Note No. 3, May 1963

Table 4.--Aerial photo volume table for hardwoods, interior Alaska[1]

(In board feet per acre)

Height[2]	Crown closure (percent)[3]										Basis: plots measured[4]
	5	15	25	35	45	55	65	75	85	95	
Feet											Number
35	0	0	0	0	0	0	0	0	0	0	5
40	0	0	0	159	334	209	43	0	0	0	12
45	0	0	111	281	390	380	193	0	0	0	6
50	0	17	208	440	602	625	435	0	0	0	16
55	0	32	331	644	887	969	805	307	0	0	9
60	0	96	485	908	1,261	1,440	1,342	864	0	0	18
65	0	174	678	1,243	1,749	2,074	2,094	1,691	742	0	21
70	0	271	917	1,665	2,375	2,906	3,113	2,862	2,008	405	5
75	0	387	1,210	2,191	3,167	3,976	4,457	4,447	3,784	2,313	5
80	0	527	1,566	2,838	4,154	5,331	6,190	6,538	6,194	4,975	--
85	0	695	1,999	3,627	5,371	7,023	8,374	9,218	9,345	8,548	--
90	0	895	2,516	4,581	6,852	9,104	11,093	12,597	13,371	13,196	--
95	0	1,129	3,130	5,721	8,637	11,627	14,420	16,769	18,409	19,069	--
100	13	1,405	3,852	7,071	10,766	14,659	18,449	21,864	24,598	26,370	--
105	52	1,726	4,702	8,657	13,283	18,258	23,264	27,985	32,102	35,298	--
110	97	2,095	5,684	10,513	16,298	22,500	28,961	35,269	41,076	46,033	--
115	149	2,523	6,823	12,669	19,670	27,461	35,654	43,868	51,723	58,820	--
120	207	3,013	8,129	15,145	23,642	33,219	43,440	53,900	64,184	73,896	--
125	274	3,566	9,623	17,985	28,204	39,843	52,432	65,528	78,700	91,465	--
130	349	4,198	11,316	21,217	33,413	47,433	62,764	78,930	95,445	111,822	--

---

[1] Gross volume per acre in International 1/4" rule (from one-foot stump to top equaling 40% of d.b.h. but not less than 8.0 inches) for all live hardwoods at least 11.0 inches d.b.h. and occasional spruce 9.0 inches d.b. = $V = -199.6288 + 0.00034\ C^2H^2 - 0.0000048\ C^3H^2 + 0.00102\ V^2_{cu.ft./a.}$ $R^2 = 0.922$. Standard error of estimate as percent of mean volume: for equation, 56.3%; for table, 86.3% (Components: balsam poplar, 59.0%; birch, 81.6%; aspen, uncertain since only 5 of the 27 aspen plots had over 500 bd.ft./a.)

[2] Average height, H, of 5 tallest aspen, birch, or balsam poplar. Interval as $62.6 \leq 65 < 67.6$.

[3] C, from micro-dot grid counts of all live trees at least 5 inches d.b.h. Interval as $60.0 \leq 65 < 70.0$.

[4] Lines contain basic data for 97 1/2-acre plots from 5 general areas.

Northern Forest Experiment Station
U. S. Forest Service
Juneau, Alaska
Research Note No. 3, May 1963